

AMENDMENTS TO THE CLAIMS

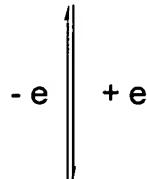
Claims 1-14 (canceled)

15. (previously presented) The optical switch of Claim 57 wherein said at least one digital dye comprises a charge complex.

16. (currently amended) The optical switch of ~~Claim 15~~ Claim 57 wherein said molecular system is based on the general model below:

Con₁—Mⁿ⁺ complex—Chromophore—Con₂

Oxidized State I, Color 1



Con₁—M⁽ⁿ⁻¹⁾⁺ complex—Chromophore—Con₂

Reduced State II, Color 2

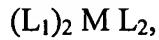
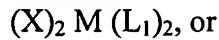
Scheme 2

where:

Con₁ and Con₂ are optional connecting units between one molecule and another molecule or between a molecule and a substrate, are either a single connecting unit or multiple connecting units, and are selected from the group consisting of hydrogen (utilizing a hydrogen bond), multivalent hetero-atoms selected from the group consisting of C, N, O, S, and P, functional groups containing said hetero atoms, saturated or unsaturated hydrocarbons, and substituted hydrocarbons;

said metal complex contains at least one hetero atom selected from the group consisting of N, P, O, S, Se, and Te, where M has two different oxidation states; and said chromophore is a natural or synthetic colorant.

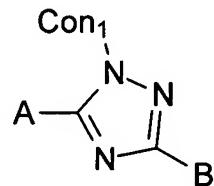
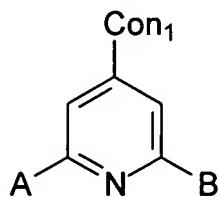
17. (previously presented) The optical switch of Claim 16 wherein said metal complex is represented by one of the following formulae:



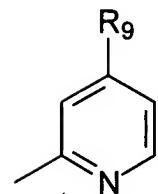
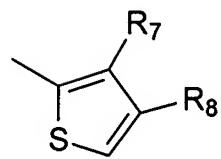
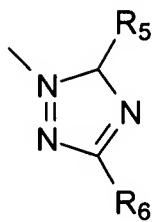
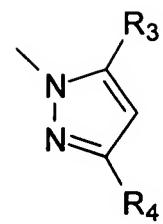
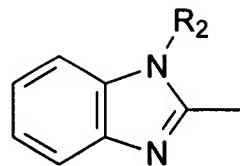
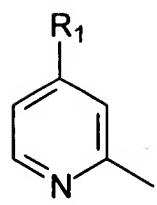
wherein M represents a metal atom selected from the metals listed in Groups IIIA, IVA, VA, VIA, VIIA, VIIIA, IB, and IIB of the Periodic Table, X represents a polar group, and L₁ and L₂ represent any hetero atom containing ligands which have at least one said connecting group Con₁ or Con₂, and n is an integer between 1 and 8.

18. (previously presented) The optical switch of Claim 17 wherein M is a Group VIII metal and wherein X is selected from the group consisting of halogen, thiocyanate, hydroxy, cyan, isocyanate, and selenocyan.

19. (previously presented) The optical switch of Claim 17 wherein L₁ and L₂ are selected from the group consisting of

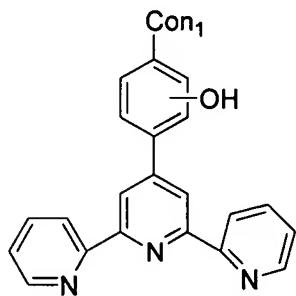
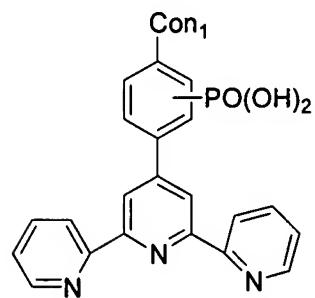
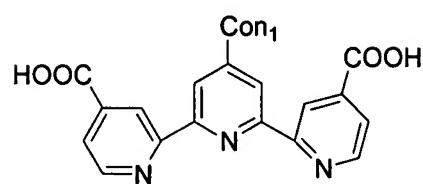
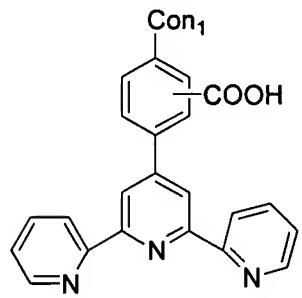
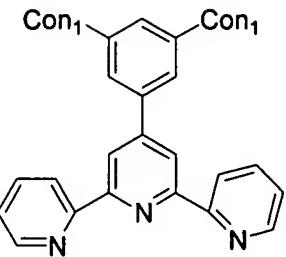
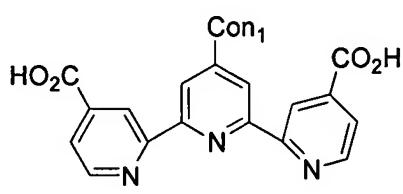


wherein A and B may be the same or different groups independently selected from H and any of the following structures:

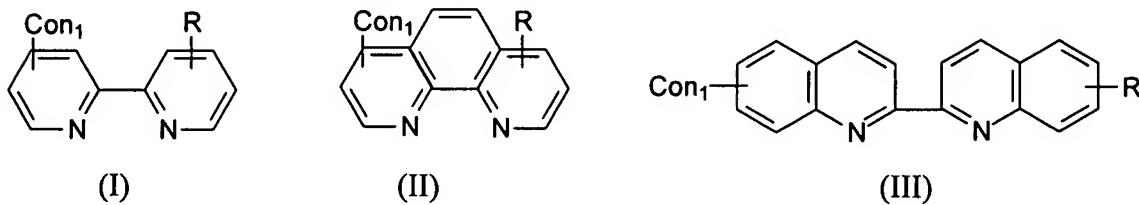


wherein R₁, R₂, R₃, R₄, R₅, R₆, R₇, R₈ and R₉ each represents a hydrogen atom or an organic subsistent such as a hydroxyl group, a lower alkyl group such as C₁-C₆ alkyl group, a lower alloy group such as C₁-C₆ alkoxy group, an unsubstituted amino group or an amino group having a substituent such as a lower alkyl group, e.g., C₁-C₆ alkyl group.

20. (previously presented) The optical switch of Claim 19 wherein L_1 and L_2 are independently selected from the group consisting of



21. (previously presented) The optical switch of Claim 17 wherein L₁ and L₂ are nitrogen-containing polycyclic compounds selected from the group consisting of bipyridines (I), phenanthrolines (II), and biquinolines (III):



where R represents a hydrogen atom or an organic substituent selected from the group consisting of hydroxyl, C₁-C₆ alkyl group, C₁-C₆ alkoxy group, an unsubstituted amino group, and an amino group having said substituent.

22. (previously presented) The optical switch of Claim 17 wherein L_1 and L_2 are selected from the group consisting of triorganophosphines and triorganophosphites having the formula



where each R_1 , R_2 or R_3 is the same or different and is a substituted or unsubstituted monovalent hydrocarbon selected from the group consisting of alkyl and aryl groups.

23. (previously presented) The optical switch of Claim 22 wherein said hydrocarbon groups contain from 1 to 24 carbon atoms and wherein said substituted aryl group contains substituent groups selected from the group consisting of alkyl, alkoxy,

silyl, amino, substituted amino, acyl, carboxyl, acyloxy, amido, sulfonyl, sulfinyl, sulfenyl, halogen, nitro, cyano, trifluoromethyl and hydroxy.

24. (previously presented) The optical switch of Claim 23 wherein said alkyl groups are selected from the group consisting of methyl, ethyl, propyl, and butyl, wherein said aryl groups are selected from the group consisting of phenyl, naphthyl, diphenyl fluorophenyl, difluorophenyl, benzoyloxyphenyl, carboethoxyphenyl, acetylphenyl, ethoxyphenyl, phenoxyphenyl, hydroxyphenyl, carboxyphenyl, trifluoromethylphenyl, methoxyethylphenyl, acetamidophenyl, dimethylcarbamophenyl, tolyl, and xylyl.

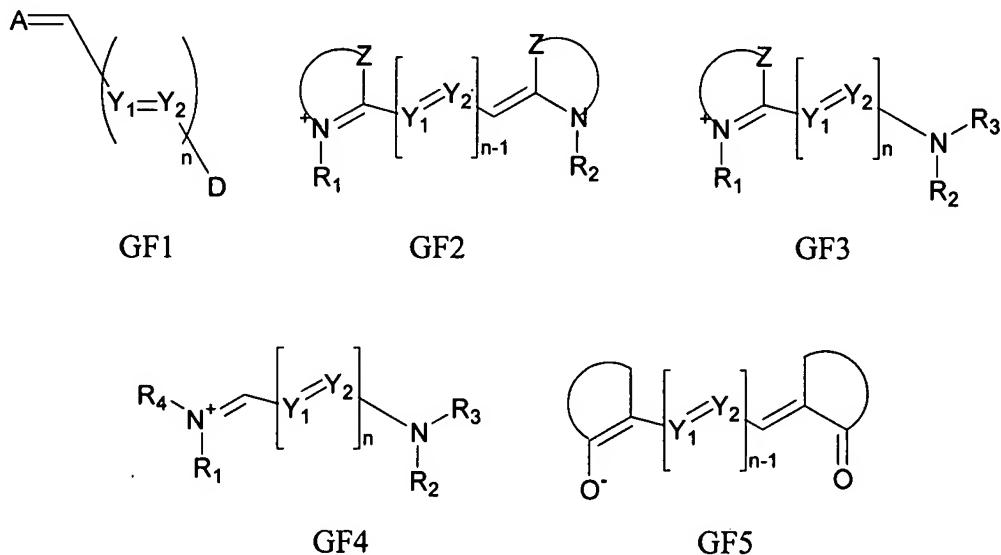
25. (previously presented) The optical switch of Claim 22 wherein said organophosphines are selected from the group consisting of triphenylphosphine, tri-p-tolylphosphine, tris-p-methoxyphenylphosphine, tris-p-fluorophenylphosphine, tris-p-chlorophenylphosphine, tris-dimethylaminophenyl-phosphine, propyldiphenylphosphine, n-hexyldiphenylphosphine, cyclohexyldiphenylphosphine, dicyclohexylphenylphosphine, tricyclohexylphosphine, tribenzylphosphine as well as (tri-m-sulfophenyl) phosphine, and (m-sulfophenyl)-diphenylphosphine.

26. (previously presented) The optical switch of Claim 22 wherein said organophosphites are selected from the group consisting of trimethylphosphite, triethylphosphite, butyldiethylphosphite, tri-n-propyl phosphite, tri-n-butyl phosphite, tris-2-ethylhexyl phosphite, tri-n-octyl phosphite, tri-n-dodecyl phosphite, dimethylphenyl phosphite, diethyldiphenyl phosphite, tri-phenyl phosphite, trinaphthyl phosphite, bis(3,6,8-tri-t-butyl-2-naphthyl)methyl-phosphite, bis(3,6,8-tri-t-butyl-2-naphthyl)phosphite, bis(3,6,8-tri-t-butyl-2-naphthyl)(4-biphenyl)phosphite, bis(3,6,8-tri-t-butyl-2-naphthyl)(4-benzoylphenyl)phosphite, and bis(3,6,8-tri-t-butyl-2-naphthyl)(4-sulfonylphenyl)phosphite.

27. (previously presented) The optical switch of Claim 17 wherein said colorant is selected from the group consisting of (a) dyes based on polyenes and polymethines; (b)

polyarylmethine dyes and their aza analogs; (c) aza [18] annulenes and phthalocyanine colorants; (d) nitro and nitroso dyes; (e) azo dyes and pigments; (f) carbonyl dyes and pigments; and (g) BODIPY dyes.

28. (previously presented) The optical switch of Claim 27 wherein said dyes based on polyenes and polymethines are selected from the group consisting of



where:

A is an Acceptor group comprising an electron-withdrawing group selected from the group consisting of (a) carboxylic acid and its derivatives, (b) sulfuric acid and its derivatives, (c) phosphoric acid and its derivatives, (d) nitro, (e) nitrile, (f) hetero atoms selected from the group consisting of N, O, S, P, F, Cl, Br, (g) functional groups with at least one of said hetero atoms, (h) saturated or unsaturated hydrocarbons, and (i) substituted hydrocarbons;

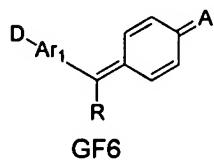
D is a Donor group comprising an electron-donating group selected from the group consisting of (a) hydrogen, (b) amines, (c) OH, (d) SH, (e) ethers, (f) saturated or unsaturated hydrocarbons, (g) substituted hydrocarbons, and (h) functional groups with at least one hetero atom selected from the group consisting of B, Si, I, N, O, S, and P, wherein said Donor group is more electropositive than said Acceptor group;

R_1 , R_2 , R_3 , and R_4 are property-tuning units selected from the group consisting of (a) hydrogen, (b) multivalent hetero-atoms selected from the group consisting of C, N, O, S, and P, (c) functional groups with at least one of said hetero atoms, (d) saturated or unsaturated hydrocarbons, and (d) substituted hydrocarbons;

Z is an optional bridging unit for connecting two adjacent aromatic rings together, selected from the group consisting of O, S, NH_2 , NHR , and CHR functional groups; and

Y_1 and Y_2 represent connecting units between said Donor and said Acceptor, and are independently selected from the group consisting of $CH=$ and $N=$ units, wherein $Y_1=Y_2$ can be a single connecting set or multiple connecting sets.

29. (previously presented) The optical switch of Claim 27 wherein said polyarylmethine dyes and their aza analogs are selected from the group consisting of



where:

A is an Acceptor group comprising an electron-withdrawing group selected from the group consisting of (a) carboxylic acid and its derivatives, (b) sulfuric acid and its derivatives, (c) phosphoric acid and its derivatives, (d) nitro, (e) nitrile, (f) hetero atoms selected from the group consisting of N, O, S, P, F, Cl, Br, (g) functional groups with at least one of said hetero atoms, (h) saturated or unsaturated hydrocarbons, and (i) substituted hydrocarbons;

D is a Donor group comprising an electron-donating group selected from the group consisting of (a) hydrogen, (b) amines, (c) OH, (d) SH, (e) ethers, (f) saturated or unsaturated hydrocarbons, (g) substituted hydrocarbons, and (h) functional groups with at least one hetero atom selected from the group consisting of B, Si, I, N, O, S, and P, wherein said Donor group is more electropositive than said Acceptor group;

Y is a connecting unit between said Donor and said Acceptor, and is either a CH= or N= unit;

Z is an optional bridging unit for connecting two adjacent aromatic rings together, selected from the group consisting of O, S, NH₂, NHR, and CHR functional group;

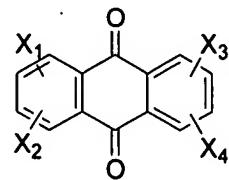
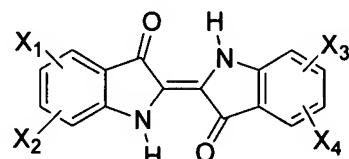
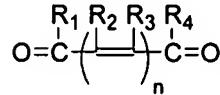
Ar₁ is aromatic ring system; and

R is selected from the group consisting of hydrogen, saturated or unsaturated hydrocarbon, and substituted hydrocarbon.

30. (previously presented) The optical switch of Claim 27 wherein in said nitro and nitroso dyes, at least one electron donor groups and at least one nitro group or at least one nitroso group are linked together through an aromatic ring.

31. (previously presented) The optical switch of Claim 27 wherein said azo dyes and pigments are compounds containing (-N=N-) which are linked sp²-hybridized carbon atoms, wherein said azo groups are either bound to aromatic rings, are aromatic heterocycles or are enolizable aliphatic groups.

32. (previously presented) The optical switch of Claim 27 wherein said carbonyl dyes and pigments have at least two carbonyl groups that are bound to sp²-hybridized carbon atoms and are selected from the group consisting of



where:

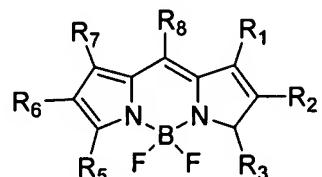
n = 1 to 4;

X₁, X₂, X₃, and X₄ are some auxochromic tuning units. They may be any one of the following: hydrogen, multivalent hetero-atoms (i.e., C, N, O, S, P, etc.) or functional

groups containing these hetero atoms (e.g., NH, PH, etc.), hydrocarbons (either saturated or unsaturated) or substituted hydrocarbons; and

R₁, R₂, R₃, and R₄ may be any one of the following: hydrogen, hydrocarbons (either saturated or unsaturated) or substituted hydrocarbons.

33. (previously presented) The optical switch of Claim 27 wherein said BODIPY dye has a structure given by

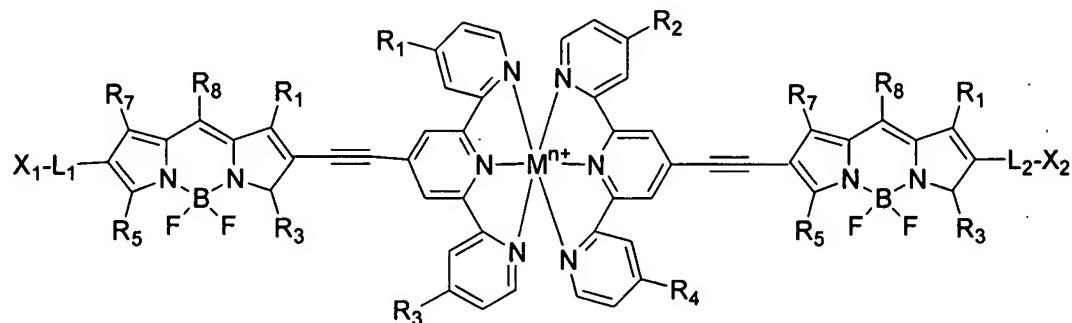


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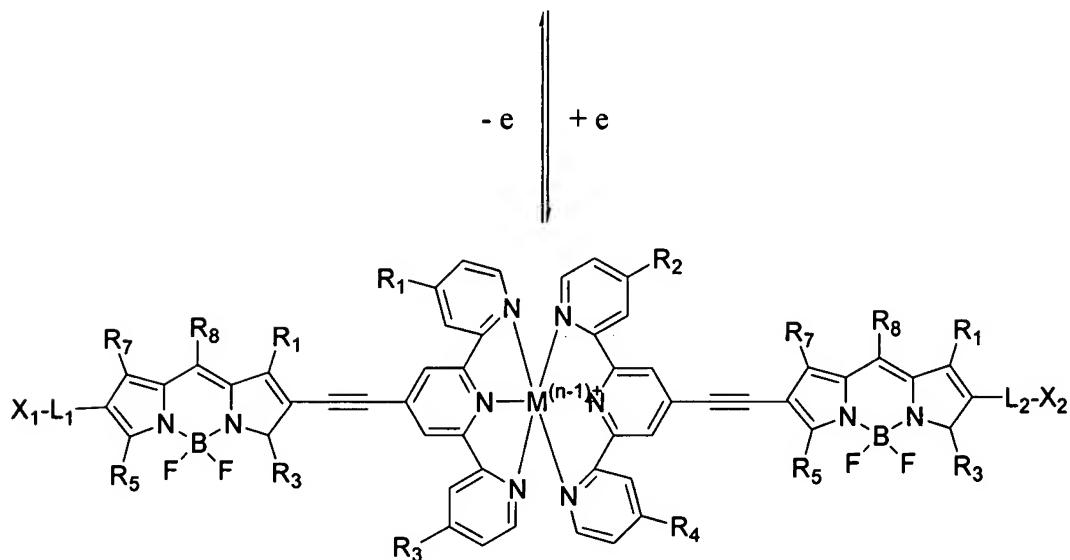
wherein

R₁, R₂, R₃, R₄, R₅, R₆, R₇, and R₈ are independently selected from the group consisting of hydrogen atom, saturated or unsaturated hydrocarbons, substituted hydrocarbons, aryl groups substituted aryl groups, and a functional group containing an atom selected from the group consisting of N, O, S, P, and As.

34. (previously presented) The optical switch of Claim 17 wherein said digital dye is represented by



Oxidized state I, Color 1



Reduced State II, Color 2

where

L_1-X_1 and L_2-X_2 are independently present or absent and if present are independently 3-mercaptophenyl, 3-mercaptomethylphenyl, 3-(2-(4-mercaptophenyl)ethynyl)phenyl, 3-(2-(3-mercaptomethylphenyl)ethynyl)-phenyl, 3-(2-(3-hydroselenophenyl)ethynyl)phenyl, 3-hydrotellurophenyl, 3-hydrotelluromethyl-

phenyl and 3-(2-(4-hydrotellurophenyl)ethynyl)phenyl, or 3-(2-(3-hydrotellurophenyl)-ethynyl)phenyl; and

R₁, R₂, R₃, R₄, R₅, R₆, R₇, and R₈ are independently selected from the group consisting of hydrogen atom, saturated or unsaturated hydrocarbons, substituted hydrocarbons, aryl groups, substituted aryl groups, and functional groups which contains at least one atom selected from the group consisting of N, O, S, P, and As.

Claims 35-52 (canceled)

53. (previously presented) The optical switch of Claim 57 wherein said digital dye has two ends and includes a linking group on at least one said end to form said molecular system.

54. (previously presented) The optical switch of Claim 53 wherein said chemical bonding is achieved with terminal groups on said digital dye selected from the group consisting of thiols, thiol-terminated alkenes, and -COOH-terminated chains or groups.

Claims 55-56 (canceled)

57. (currently amended) An optical switch comprising:

a first electrode;

a second electrode located opposite said first electrode; and

a molecular system connected to said first electrode and connected to said second electrode, said first and second disposed between a pair of electrodes capable of generating an electric field, said molecular system providing two different colors based on two different oxidation states of at least one digital dye in said molecular system, said digital dye having an optical change resulting from an electrochemical oxidation/reduction reaction.

58. (original) The optical switch of Claim 57 wherein said molecular system changes between a transparent state and a colored state.

59. (original) The optical switch of Claim 57 wherein said molecular system changes between one colored state and another colored state.

60. (original) The optical switch of Claim 57 wherein said molecular system changes between one index of refraction and another index of refraction.

61. (original) The optical switch of Claim 57 for assembling devices selected from the group consisting of displays, electronic books, rewritable media, electrically tunable optical lenses, electrically controlled tinting for windows and mirrors, and optical crossbar switches for routing signals from one of many incoming channels to one of many outgoing channels.

Claims 62-73 (canceled)

74. (previously presented) A plurality of the optical switches of Claim 57 forming a display device.